RECENT QCD RESULTS FROM THE CDF AND DØ EXPERIMENTS AT THE TEVATRON*

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Recent QCD result obtained from the Tevatron Run II data are reported. The CDF and DØ experiments at the Tevatron has used $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV to measure the inclusive jet and dijet mass spectra.

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1. Introduction

Measurements of jet production cross section can be used to test QCD predictions for parton-parton scattering and to constrain the parton density functions (PDF) of the proton, particularly the gluon distribution.

The increase in center-of-mass energy from 1.8 to 1.96 TeV is expected to bring a significant increase in the jet cross section at high $p_{\rm T}$ (by factor of 2 at $p_{\rm T} \approx 400$ GeV) according to the NLO QCD prediction. With a data sample similar to that obtained in Run I, both CDF and DØ collaborations are able to measure jet production at much higher $p_{\rm T}$ than those possible in the previous run. All preliminary results from CDF and DØ are based on data samples collected during the time period from February 2002 to July 2003 at Fermilab Tevatron Collider at $\sqrt{s} = 1.96$ TeV.

2. Inclusive jet cross section

The inclusive jet cross section measurement from DØ is based on a data sample which represents an integrated luminosity of approximately 34 pb^{-1}. These data were collected using four inclusive jet triggers. Each trigger requires a localized energy deposited in the calorimeter and a reconstructed jet with $p_{\rm T}$ above one of the following thresholds: 25, 45, 65, or 95 GeV.

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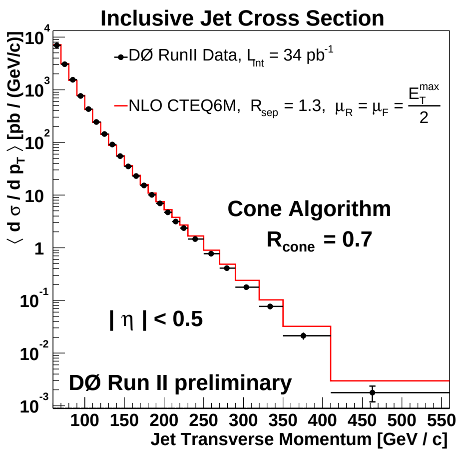
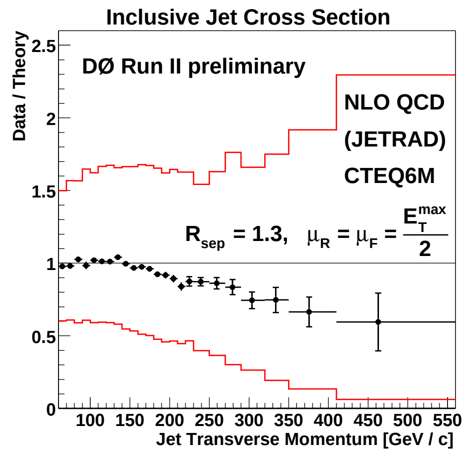


(a)



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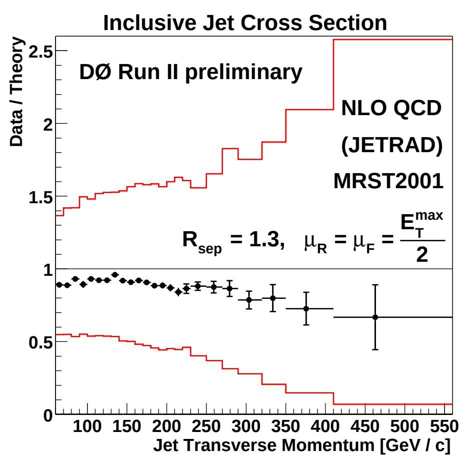

(c)

Fig. 1. DØ inclusive jet cross section as a function of jet p_{T} (a). The inclusive jet cross section shown as data/theory as a function of jet p_{T}, two PDFs were used in the theory calculation: CTEQ6M (b) and MRST2001 (c).

The jets are reconstructed in the DØ calorimeter using an iterative cone algorithm with $\Delta R = \sqrt{\Delta\eta^2 + \Delta\varphi^2} = 0.7$ [1]. The energy from the collision not associated with the hard scattering (underlying event energy) is subtracted from the total jet energy. The jet energy scale was defined using information from $\gamma + \text{jet}$ events, low bias triggers, and Monte Carlo simulations. There are large statistical uncertainties and substantial systematic uncertainties in this energy scale determination that increase with energy due to extrapolation. These are principally caused by small $\gamma + \text{jet}$ statistics above 200 GeV. This is the dominant systematic uncertainty in the jet cross section measurements. The jet measurements are restricted to the pseudorapidity range $|\eta| < 0.5$ to limit the impact of these uncertainties. The jet $p_{\rm T}$ resolution was measured from the $p_{\rm T}$ imbalance in dijet events.

A primary vertex with at least 5 tracks and $|z_{\rm vtx}| < 50$ cm is required to ensure a good jet energy measurement. The jet selection was based on calorimeter characteristics to reduce the number of misidentified jets. To remove rare instrumental backgrounds to high $p_{\rm T}$ jet events, we require $\not{E}_{\rm T}$ to satisfy the relation $\not{E}_{\rm T} < 0.7\, p_{\rm T}(\text{leading jet})$[1]. The cuts efficiencies are estimated from data to be 78 % for the vertex selection and 97 % for the jet selection.

The observed inclusive jet differential cross section as a function of jet $p_{\rm T}$ is shown in figure 1(a). The 10 % luminosity error, which is correlated bin-to-bin, is not shown.

The observed cross sections were compared with the results of a NLO pQCD calculation made with JETRAD [2] Monte Carlo generator using CTEQ6M [3] and MRST2001 [4] PDF. The factorization and renormalization scales have been set equal to $p_{\rm T}/2$ of the leading jet in the event and $R_{\rm sep}$ has been set to 1.3. Linear comparisons of the calculation to the data are presented in figure 1(b), (c). Within errors, there is an agreement with the theory.

The CDF collaboration measured the inclusive jet cross section with 177 pb^{-1}. To obtain results in a prompt fashion, the CDF collaboration uses the same techniques as in Run I inclusive jet analysis [5], when possible. Jets are reconstructed using the fixed cone algorithm with a radius $\Delta R = 0.7$. The inclusive jet cross section includes all jets in an event in the pseudorapidity range $0.1 < |\eta| < 0.7$. The following data quality cuts are used: events with large $\not{E}_{\rm T}$ are excluded to avoid background from cosmic rays, and the event vertex is required to be within 60 cm of the center of the detector. The measured spectrum is corrected for calorimeter response and underlying event energy. The jet energy scale is calibrated to the known energy of jets in Run I by requiring the $p_{\rm T}$ balance of central photons to the central jets to be the same in Run II and Run I.

The measured inclusive jet cross section is shown in figure 2(a) and compared to the NLO QCD expectation determined using CTEQ6.1 [6] PDF. The data cover the $E_{\rm T}$ range from 44 up to 550 GeV, extending the upper

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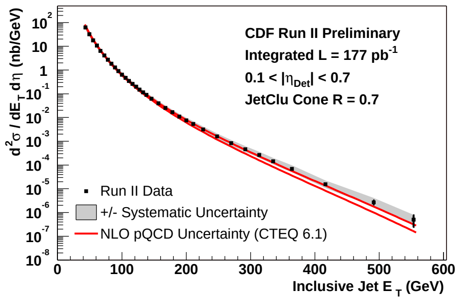
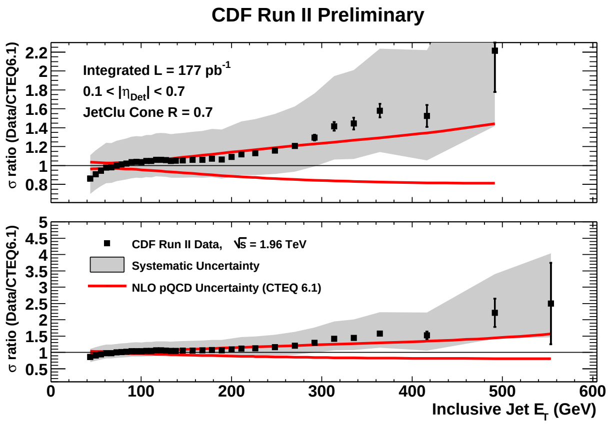
[1] $\not{E}_{\rm T}$ is the missing energy transverse to the beam direction.



(a)



(b)

Fig. 2. CDF inclusive jet cross section as a function of jet p_{T} (a). the band shows the change in cross section due to a 5 % jet energy scale shift. Ratio of Run II/Run I cross sections compared to the QCD prediction using CTEQ6.1 (b). The lines show the uncertainty on CTEQ6.1.

limit by almost 150 GeV from Run I. Linear comparisons of the inclusive jet cross section measured in Run II and Run I is shown in figure 2(b). The cross section in Run II is larger than that in Run I due to the higher center-of-mass energy. This effect is especially prominent for high E_{T} jets.

3. Dijet mass distribution

The DØ collaboration measured the dijet cross section as a function of the dijet invariant mass. The size of the data sample, requirements for the events and the algorithm used for jet reconstruction are the same as for the inclusive jet cross section measurement. The observed dijet differential cross section as a function of dijet mass is shown in figure 3(a). The inner bars

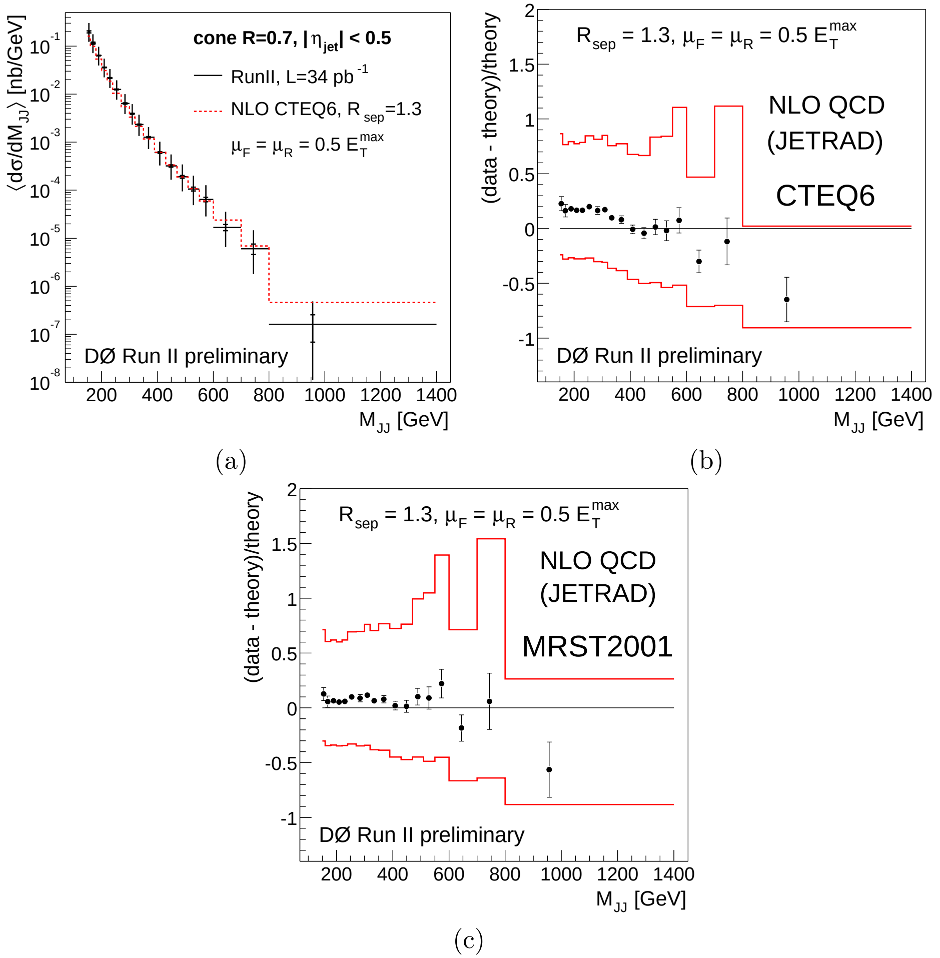
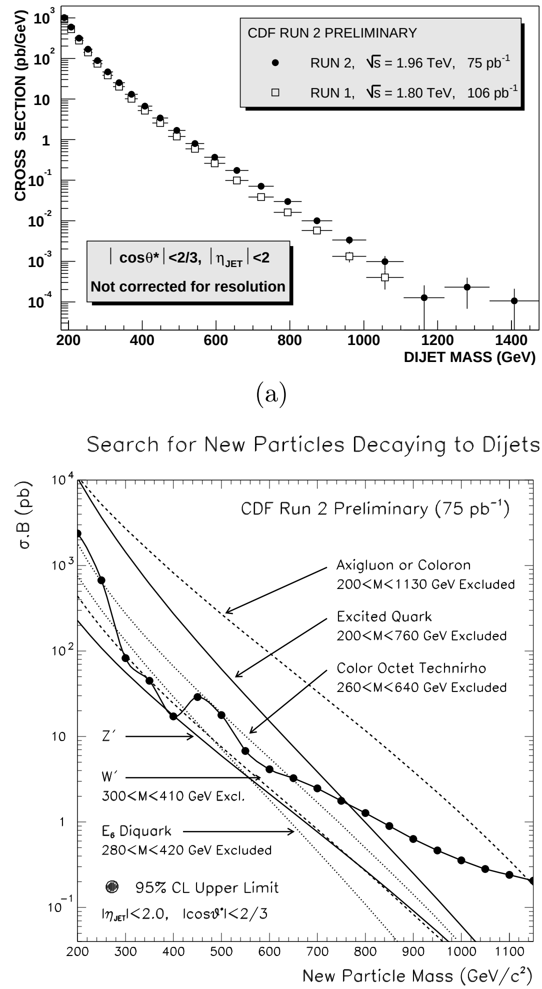


Fig. 3. DØ dijet cross section as a function of dijet mass (a). The dijet cross section shown as (data–theory)/theory as a function of dijet mass, two PDFs were used in the theory calculation: CTEQ6M (b) and MRST2001 (c).

represent experimental statistical errors and the outer bars are systematic uncertainties. The 10 % luminosity uncertainty is not shown. Linear comparisons of the theoretical predictions using CTEQ6M and MRST2001 PDF to the data are presented in figure 3(b), (c). There is an agreement within the errors with the predictions.

The CDF collaboration used 75 pb^{-1} of jets data to search for new particles decaying to dijets by using a general search for narrow resonances and a direct search for several kinds of new particles: axigluons ($A \rightarrow q\bar{q}$), excited states of composite quarks ($q^* \rightarrow qg$) and E_6 diquarks ($D(D^c) \rightarrow \bar{q}\bar{q}(qq)$).



(a)

(b)

Fig. 4. CDF Run II dijet mass distribution compared to Run I data (a). The 95 % C.L. upper limit on the cross section times branching ratio for new particles decaying to dijets versus mass of the new particles (b). The limit includes systematic uncertainties.

The observed dijet differential cross section as a function of dijet mass is shown in figure 4(a). Fitting the mass spectrum with a simple background parametrization and a mass resonance allows to obtain a 95 % confidence level upper limit on the cross section for new particles as a function of mass. The limit is shown in figure 4(b). A dijet event is defined as an event with two largest E_{T} jets, restricted to the pseudorapidity region $|\eta| < 2.0$. In addition, dijets are required to satisfy the condition $|\tanh((\eta_1 - \eta_2)/2)| < 2/3$ to suppress QCD background. CDF excludes at 95 % confidence level axigluons for $200 < M_A < 1130$ GeV/c^2, excited quarks for $200 < M^* < 760$ GeV$/c^2$ and E_6 diquarks for $280 < M_{E6} < 420$ GeV$/c^2$.

It is a pleasure to thank all participants in the CDF and DØ collaboration for the extraordinary amount of effort that they have made to bring to reality the Summer 2003 measurements reported in these proceedings.

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